Request for Proposal Response to:

SKANSKA

Arlington High School
Building Automation Consultant

Smart Building Assurance Program™

Experience Better Automation

Interval Data Systems, Inc.

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Introduction

Interval Data Systems, Inc. (IDS) is pleased to respond to Skanska's request for an automation consultant for Arlington High School. Since IDS' founding we have had one focus, making buildings operate as designed. It required many years of analysis work to identify the most common deficiency affecting building performance—the software that runs the building. It took additional years to define a process that assures that buildings operate consistent with design intent for the life of the building. This process, the Smart Building Assurance Program (SBAP), uses software engineering best practices to design, implement, maintain, and train personnel for automation software.

IDS' approach to achieving desired operations is by focusing efforts on the Sequences of Operation in the design phase to assure well-structured programming instruction. The construction phase is used to assure the automation programming delivered is as specified. The Close-Out/Warranty period is used to identify any software defects and correct them. We have found if you do not get it right by the end of warranty it is highly unlikely the building will ever meet health and safety requirements at the lowest energy cost.

MSBA's post occupancy study identified operator training as a weak link in the building delivery process. Training Arlington's facilities personnel has been addressed extensively in the Close-Out/ Warranty period as well as the Ongoing Monitoring periods. There are quarterly training sessions planned during the Close-Out/Warranty covering a wide range of topics including the use of findings from IDS' quarterly reviews. IDS uses the case study method of training, with your data. Hot/cold calls become subject matter to demonstrate the mechanisms of root cause diagnosis. Complementary to the formal training sessions, facilities staff attendance in the Sequences of Operation meetings with BALA and review meetings later with the control contractor, would be beneficial.

As part of this response IDS is including some insights from our preliminary automation analysis, input we provide owners at the 60% CD level. Additionally, we have prepared a matrix that maps ASHRAE Guideline 36 applicability to the equipment types planned for this project.

Qualifications & Experience History

- Consultant must be able to demonstrate Subject Matter Expertise to assure building operates consistent with design intent by the end of the warranty period and continues to operate in that fashion.
- Focus of scope is Building Management System and associated MEP systems that contribute to the energy performance of the building.
- Demonstrate use of Software Engineering Discipline in order to achieve operational design intent by the end of warranty.
- Demonstrate the ability to work with architects, design/consulting engineers, control contractors, commissioning agents, and facilities department personnel.
- Demonstrate a plan/process/approach to achieve required goal of continuous operation consistent with design intent.
- Must include Energy Management Analytic Software experience and ability to deliver valuable insights from the data.

Subject Matter Expertise

Over the past 16 years, IDS has evaluated operations of hundreds of buildings. We make extensive use of operating data from the building's utility meters, owner's meters, and control system. After tens of thousands of hours of analysis, we discovered that around 80% of the operational issues—those that cause energy waste and excessive maintenance—are unintentionally created during the design and construction phases only to show up after building turnover. Most importantly, we discovered that it was not an equipment or mechanical design problem, but a software problem. Deficient automation software leaves the school functioning inadequately for years.

Analysis after analysis pointed to the root cause(s)—the sequences of operation (SOO) and/or the programming of the sequences. Even minor flaws deteriorated into poor operations that required enormous amounts of time to fix, if it ever got fixed. We found many SOO too vague and sometimes with incomplete or flawed logic. This lets the control contractor fill in the blanks and they will do whatever is easiest/fastest. We also observed that each engineering firm evolves their own SOO. The result is that each building has a different theory of operations, which complicates managing ongoing operations for the facilities department. Another contributing factor is that operators were not trained how to operate buildings, they were trained to fix equipment. To be effective, our training sessions always starts with ASHRAE fundamentals, engineer's design, SOO, and then we connect the dots between BAS screens, equipment problems and operational data.

Our cofounder, Gregory Cmar, is one of the 25 voting members of the ASHRAE Guideline 36 High Performance Building SOO committee. He is an active participant in evolving the standard, and constantly provides feedback based on deploying the G36 approaches in IDS projects. Greg is a leading voice on the committee for areas of winter operations and optimal start.

Software Engineering Discipline

To address the inherent deficiencies in the industry's process for automation delivery, IDS applies best practices from the software engineering discipline. Software is typically developed and delivered by one company who oversees the software's design, programming, and quality assurance, not spread over three or four organizations (the norm in the HVAC world), none of whom are practiced in the rigors of software engineering nor own the final delivery.

The first step in software engineering is to make sure the software specification (SOO) is structured, well defined, and unambiguous. The software industry has developed standards to address commonly needed functions to avoid re-inventing the wheel and to deliver consistency to the customer. ASHRAE Guideline 36 does this for HVAC SOO. G36 provides a consistent methodology for the industry to follow to deliver better sequences that fully take advantage of modern equipment, operate as efficiently as possible, and are easy to maintain.

IDS combines our software expertise (we architected, designed, and built our EnergyWitness™ analytics platform) with the combined controls expertise of ASHRAE to integrate the design engineer's SOO with G36 and to deliver an explicit specification to the control contractor that meets high performance standards for health, comfort, and energy efficiency.

During all our analysis sessions we observed that operator screens were not designed in such a way that reinforced good practices and make it easy to follow design intent. The BAS user interface must help institutionalize the right way to run the school.

Software development and quality assurance (QA) are performed by the control contractor and commissioning agent in the HVAC world. IDS works with controls contractors and commissioning agents to assure the automation is delivered as specified. This takes the form of software design reviews so that the programmers have a clear understanding of what is expected, and code reviews to verify that what was specified is what is delivered.

Preliminary SOO Review at 60% CD

Based upon RFP information we've identified the following functional requirements of the systems and the value IDS will provide to the automation delivery (also see Table 1: Sequences of Operation by System):

1. A General section (see Attachment 1) will provide standard definitions and approaches that function across systems. These instructions for the control programmer provide a consistent framework for the code. Parts of the General section will deal with all systems, ventilation zones, thermal zones, and zone groups. It will address at a minimum:
    a. Zone Groups (areas of the school designed to operate together)
    b. Modes of Operation (occupied, unoccupied, warmup, cool-down, setback, etc.)
    c. Trim & Respond (an efficiency mechanism to control temperature and pressure resets based on closed-loop feedback, e.g. VAVs providing feedback to air handler)
    d. Alarms (hierarchical design to reduce alarm overload; a major alarm advancement)
2. ASHRAE RP-1711 addresses SOO for the heat pumps providing central heating and cooling for the school. Given New England weather, IDS has observed operational problems automating central plant operation in spring and fall caused by switching modes too often. IDS will adapt the SOO with RP-1711 and G36 concepts to:
    a. Avoid outside temperature switching between heating, heating/cooling, and cooling modes more than once per day in order to avoid operational problems seen elsewhere.
    b. Engage electric boilers by outside temperature and season.
    c. Apply G36 for zone group and alarm schedules.

3. There is currently increased discussion of the role aerosolized virus particles play in COVID-19 transmission, ventilation and filtering are important to mitigate risk of transmission.
    a. It is unknown what impact COVID-19 (or other airborne infectious diseases) will have at the time when AHS will open. One recommendation is an “epidemic mode” of operation that can very easily be engaged to perform functions such as building purges and enhanced ventilation if the requirement exists or disengaged to allow for standard operation when/if not needed.
4. Ventilation to classrooms is from dedicated rooftop units serving 4-pipe fan powered terminal units. ASHRAE G36 treats the terminal units as single zone AHU and the HRU as a VAV DOAS (dedicated outdoor air system) system.
    a. Will need to discuss the ventilation strategy with BALA as current documentation suggests that classroom ventilation is unclear below 50°F. The design intent review session with BALA will address and clarify ventilation.
    b. Four different styles of VAV (fan powered, fan powered with coil, electric reheat, hot water reheat) are all covered by ASHRAE and SOO will reflect G36 recommendations to optimize energy efficiency both through their own direct operation and by providing temperature and airflow feedback to the air handler via Trim & Respond to optimize supply air temperature and static pressure resets.
5. System configurations for areas served by heat recovery units (HRUs) are all treated in G36 like single zone units and the SOO will reflect that.
    a. The current specifications call for MERV 8 and MERV 13 filters; ASHRAE’s COVID-19 recommendations are for MERV 13 or higher filters, but ASHRAE hasn’t provided guidance related to filtering both supply and return air. This will be part of the design intent discussion with BALA.
6. The administration and preschool areas are served by variable refrigerant flow (VRF) systems. ASHRAE G36 does not have a standard SOO for VRF systems, but these systems come with integrated controls from the manufacturer that work well. IDS will utilize the manufacturer’s BACnet interface and integrate zone groups and alarm scheduling from G36.
    a. The VAV boxes that provide ventilation to these areas will follow normal G36 recommendations for ventilation and optimal heating and cooling operations.

Experience with Engineers and Contractors

Automation consulting requires that one work with the team responsible for delivering a new school. That involves the owner, owner’s project manager, engineer, control contractor, Cx agent, and building staff. IDS works with these groups on every project. Some of the projects are described below:

- **Belmont Middle and High School—**Belmont engaged IDS as the automation consultant for their new middle and high school. We worked with BALA and Belmont’s OPM to update the specifications and SOO to ASHRAE G36 levels. This engagement is nearly identical in scope to what Arlington is requesting. The project is currently in the construction phase, but BAS programming has not occurred yet.

- **Commonwealth of Kentucky**—IDS is Kentucky's energy efficiency partner (service) and EEMS platform (technology) provider for their Central Energy Management and Control System (CEMCS) program. To date IDS has analyzed (operational assessments, similar deliverable as included in this response scope during warranty and ongoing monitoring) 140+ buildings, including schools, offices, labs, libraries, and more, identifying 900+ ECMs. These numerous operational assessments repeatedly pointed to the importance of well written SOO coupled with precision programming. To date the CEMCS program has saved 937 million kBtu. Our services span design, construction, commissioning, warranty period and ongoing monitoring. We work with a wide variety of design engineers, controls manufacturers, controls contractors, Cx agents, and facilities personnel across Kentucky. The program has had a profound change on how Kentucky approaches new construction, using IDS to review and update the SOO as needed, review the automation delivered, and analyze operations during the warranty period so that all warranty issues can be addressed. Facilities staff is constantly trained with monthly online training sessions.

- **UMass Medical Center, Worcester**—IDS has analyzed four science/lab buildings. In one case we found 150,000 cfm of excessive, continuous airflow, costing approximately $400K/year … in a three-year-old building. To remediate, we've rewritten the SOO to comply with ASHRAE G36, and have overseen the changes made by UMass and its control contractor. This has required many iterations of automation programming to deliver acceptable code that functions as the design specifies. The experience we have here is particularly pertinent to today's high school designs as they frequently have STEM characteristics.

- **Leggat McCall Properties**—IDS worked with their engineer to upgrade and adapt the SOO for LMP's Biological Science Building to improve the specificity and modernize the sequences, consistent with ASHRAE's Guideline 36.

- **Williams College**—A new science building on campus is using more energy than predicted by the energy model. IDS is involved in a project to determine why, by reviewing the SOO, determining if the delivered automation complies with the SOO, and make recommended improvements to reduce energy.

Energy Management Analytic Software

IDS is the creator of EnergyWitness, an enterprise-level building analytics software platform that includes fault detection, detailed diagnostics, meter analysis, energy tracking, and ECM tracking. Our expertise in software engineering discipline and how it should be applied to controls automation software comes from our experience as software developers.

The energy and metering data give an overall picture of efficiency. The fault detection provides an easy-to-understand scoring system showing how aspects of the building function and point maintenance personnel to the problem areas. The diagnostics allow a deep dive into how each system and piece of equipment operates. EnergyWitness is the key tool we use when providing operational analysis and recommendations. A small sampling of analytics screens from EnergyWitness are shown below.

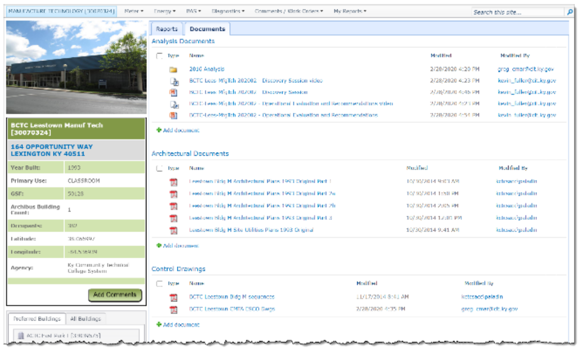

Figure 1: A document management system keeps all analysis reports and drawings immediately available, right from the building homepage.

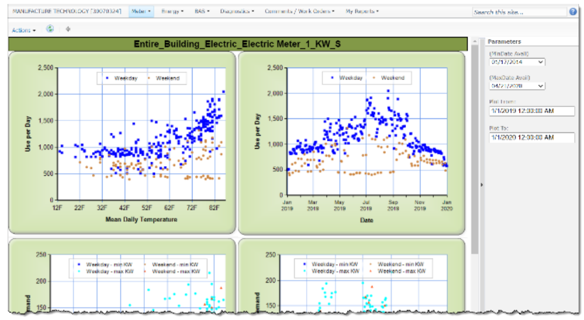

Figure 2: One of several meter analytics shows daily consumption and demand by outside temperature and across time.

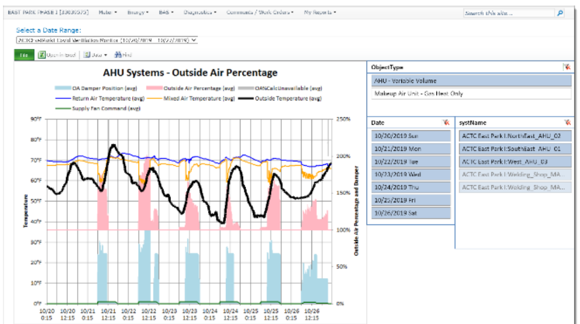

Figure 3: The COVID Ventilation Monitor diagnostic shows what percentage of outside air is being brought into the school. All diagnostics are custom configured to reflect the mechanical design of the school. They cover primary heating/cooling systems, secondary systems (AHUs, HRUs, exhaust), and terminal systems (VAVs, etc.)

Figure 4: My Reports provides a full ad hoc trend reporting capability where any data can be combined and the user can easily move through time. Reports and data can be exported, and report definitions saved for future use.

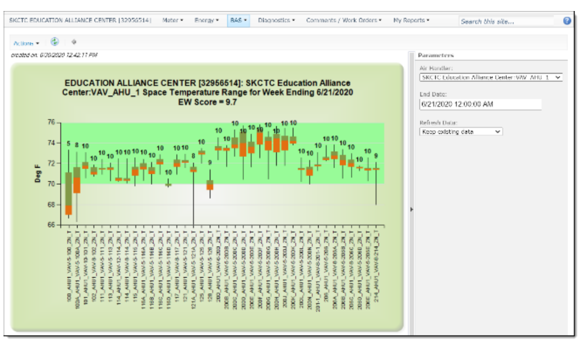

Figure 5: The Comfort report is one of the fault detection reports that instantly shows how well comfort is maintained across all zones served by an AHU. Outliers are easily identified, temperature consistency is easily seen, and a simple scoring system provides an objective measurement of how well comfort is maintained.

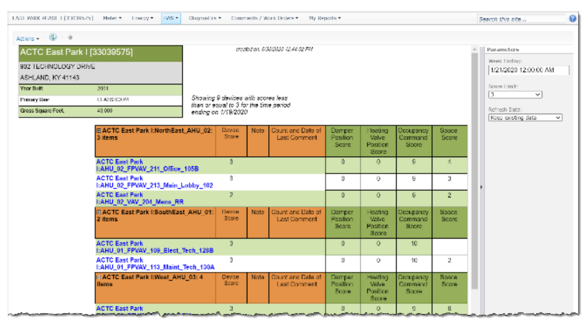

Figure 6: The Low Scores fault detection report summarizes all faults to provide a summarized view of what units are exhibiting problems that require maintenance staff attention.

EnergyWitness is included with our solution and will become operational near the end of each phase of construction, capturing a permanent record of operation. EnergyWitness will be made available to commissioning, engineering, and facilities personnel. A permanent record of operations is always valuable in the Close-Out/Warranty period to facilitate resolution of operational issues.

Scope of Services

Design Phase Input

- Provide recommendations on engineer of record's Sequence of Operations (SOO) specifications to adapt to ASHRAE's latest High-Performance Building SOO guidelines.
- Provide recommended specifications and control diagram mark-ups to engineer of record to incorporate alarm hierarchy and reporting strategies meeting ASHRAE protocols into the construction documents. The alarm reporting shall be designed to support building operator by identifying operating issues, maintenance items, and energy optimization opportunities.
- Review engineer of record's SOO and provide specific recommendations to result in an unambiguous SOO, with the goal of ensuring accurate and comprehensive implementation by the Control Contractor.
- Identify gaps in SOO and provide recommended SOO to achieve comprehensive SOO.
- Recommend BAS graphics such that it makes it simple to use for operators and provides functionality to achieve operational performance goals with the least amount of knowledge.
- Define operational acceptance criteria.
- Review metering requirements integrated into the building design and make recommendations for adjustments to metering scope required to accurately monitor building performance using BMS and vendor supplied analytics software.

The scope of our design input for all AHS project phases will include the following. See Work Plan for additional details.

1. Combined kickoff and design intent meeting with BALA. The purpose of the meeting is to make sure IDS fully understand mechanical design intent. IDS will require all pertinent drawings so they can be reviewed in advanced. Even though we will provide design intent training (at close-out/warranty) we encourage Arlington Facilities staff who'll be operating the school to attend this session.
2. Integrate engineer's SOO paragraphs for each equipment type with ASHRAE G36 High Performance SOO to provide specific, unambiguous instructions to the control contractor. (See Table 1 for G36 adaptations by equipment type.) We plan five working sessions with BALA to communicate IDS input. The work plan shows the intervals between sessions. Three of the working sessions are planned prior to the 90% documents, and two more for the final bid package. (See *Attachment 1: Work Sample—Pages from Updated SOO* for example.)
3. Specify the BAS/metering data and IT requirements for the analytic system. IDS will specify the data required for collection for analytic purposes (digital twin creation, fault detection, diagnostics, operational acceptance criteria). This includes defining trend points required (interval, change of value, analog, digital), assuring a proper data historian from the BAS vendor, data exporting functions, and IT requirements to allow data to be transmitted to an external server.
4. Specify how special events outside of standard operating hours are handled. For example, a night or weekend auditorium event should be easy for building operators to manage, automatically conditioning the auditorium and its related areas (lobby, rest rooms, backstage areas, etc.) through a simple scheduling interface.

5. Make recommendations to improve the integration between the lighting system, specifically the occupancy sensors, and the HVAC system to optimize energy usage in unoccupied rooms.
6. Identify the appropriate number of meters and their alignment with served areas suited for the energy management tracking and building performance monitoring.
7. Define Operational Acceptance Criteria to cover operating performance (e.g. comfort, ventilation, scheduling, efficiency), proper programming of sequences (e.g. trim & respond, night setback, ASHRAE 62.1-compliant ventilation), graphics and user interface requirements, alarm management, and data for analytics. (See *Attachment 2: Work Sample—Acceptance Criteria Matrix* for sample.)

Table 1: Sequences of Operation by System

	Quantity	Serves	Applicable ASHRAE Section #'s
	All		Guideline 36: Section 5.1 - General Section 5.2 - Generic Ventilation Zones Section 5.3 - Generic Thermal Zones Section 5.4 - Zone Groups
Primary Plant			
Air Cooled Heat Pumps	2 units / 40 compressors	Hot Water and Chilled Water Loops	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
Air Cooled Chillers	2 Units / 12 compressors	Chilled Water Loops	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
Electric Boilers	2	Hot Water Loops	RP-1711: Section 5.3 - Hot Water Plants Section 5.3.2 - Plant Enable/Disable Section 5.3.4 - Boiler Staging Section 5.3.4 - Hot Water Reset
Boiler Pumps	4	Boiler Plant Primary Loop	RP-1711: Section 5.3 - Hot Water Plants Section 5.3.6 - Primary Hot Water Pumps
Hot Water Pumps	6	Building HW Loops	RP-1711: Section 5.3 - Hot Water Plants Section 5.3.6 - Secondary Hot Water Pumps
Chilled Water Pumps	10	Building CHW Loops	RP-1711: Section 5.2 - Chilled Water Plants Section 5.2.7 - Secondary Chilled Water Pumps
Single Zone AHU			
Heat Pump	2	Ceiling Mount AC Units	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
Ceiling Mount AC Units		Spaces	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
Refrigerant Fan Coil Unit (VRF)		Admin, Preschool	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
H&V Units	1	Kitchen Hood	Guideline 36: Section 5.15 - Air Handling Unit System Modes; Section 5.18 - Single Zone Air Handling Unit
Multiple Zone VAV			
Energy Recovery Units	4	Ventilation for Admin and Preschool VRF's	Guideline 36: Section 5.15 - Air Handling Unit System Modes Section 5.16 Multiple Zone Air Handling Unit
Heat Recovery Units	15	Ventilation for Classrooms, Auditorium, Stage, Music, Gym, Lockers, Cafeteria and Lobbies	Guideline 36: Section 5.15 - Air Handling Unit System Modes; Section 5.16 - Multiple Zone Air Handling Unit or Section 5.18 - Single Zone Air Handling Unit
Heat Recovery Condensing Unit	10 units /43 condensers	HRU-3, 6, 7, 8, 9, 11, 12, 13, 14, 15	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
Heat Recovery Condensing Unit	5 units /19 condensers	HRU-1, 2, 3, 4, 8	Manufacturer's SOO with Zone Groups and Alarm Scheduling from G36
Fan Powered Terminal VAV Coil Box			Guideline 36: Section 5.10 - Series Fan-Powered Terminal Unit, Variable Volume Fan; Proposed Addenda: FCU
Fan Powered Terminal VAV Box			Guideline 36: Section 5.10 - Series Fan-Powered Terminal Unit, Variable Volume Fan
VAV Terminal Box - Electric Reheat			Guideline 36: Section 5.6 - VAV Terminal Unit with Reheat
VAV Terminal Box - Hot Water Reheat			Guideline 36: Section 5.6 - VAV Terminal Unit with Reheat
VAV Terminal Box - Return/Exhaust			Guideline 36: Section 5.5- VAV Terminal Unit, Cooling Only

Construction Phase

- Review and provide comments on Controls Contractor's submittal package for conformance to Design Specification.
- Review SOO and Control System Display requirements to Controls Contractor to facilitate their achievement of their requirements.
- Review of automation codes written by Controls Contractor, provide comments, verifying against design intent.
- Support Commissioning Agent with data analysis from analytics software.
- Review and provide comments on customized data feeds to building dashboards installed for occupant information.

During each construction project phase (Project Phases 1, 2, and 3) IDS will perform the following scope of services. See Work Plan for additional details.

1. Review control contractor's submittal for winning vendor. IDS will present conformance/non-conformance summary. As an option, IDS can review multiple control contractor bids and provide feedback to the selection committee.
2. IDS will review control contractor's comprehension of the specification and report findings to Owner. For purposes of this RFP, we assume that all project phases will be reviewed at this time rather than control submittals at each phase.
3. IDS will respond to specification questions from the awarded control contractor (via the OPM) while the control system is in development and throughout the construction phase.
4. Prior to installation of the terminal system programs, IDS will review control contractor's automation code. Automation code will be reviewed for those terminal systems implemented during each phase's installation.
5. Establish ongoing data collection from BAS system to EnergyWitness. Note, to automate data transfer from the BAS to EnergyWitness, the IT network needs to be in place with the ability to transfer data outside the AHS firewall.
6. Create digital twin building data model to prepare for automated fault detection and diagnostics. The digital twin will include:
    a. Engineering data (e.g. space area and volume, what equipment serves each space, other pertinent engineering requirements) is combined with trended automation system data to allow the virtual entity to exist simultaneously with the physical.
    b. Configure EnergyWitness analytics (see Figures 1 through 6 in Energy Management and Analytics Platform section for examples of Fault Detection and Diagnostic Reports). The following systems will be configured for EnergyWitness.
        i. Primary Systems—Air cooled 30-ton heat pumps, chilled water distribution, hot water distribution, chiller-heat building distribution.
        ii. Secondary Systems—Single Zone AHU (heat pump, ceiling mount AC units, VRF Kitchen Hoods, Energy Recovery Units, Heat Recovery Units, Heat Recovery Condensing Units (both configurations).
        iii. Terminal systems—Fan Powered Terminal VAV Coil Box, Fan Powered Terminal VAV Box, VAV Terminal Box w/electric reheat, VAV Terminal Box w/HW reheat, VAV Terminal Box R/E.

   iv. Configure Fault Detection reports for comfort, valve and damper operations, and run hours (scheduling), along with a Low Scores report that provides a consolidated view of terminal systems equipment deficiencies.

7. Make EnergyWitness' analytics available to all owner identified users.
8. Support Commissioning agent by providing training to apply EnergyWitness to commissioning needs.
9. Review of HVAC operating screens and metering reports. Provide feedback to AHS and control contractor to assure required content and ease of use requirement. Validate that BAS system interface allows operators to adjust appropriate set points if necessary and can easily schedule non-standard occupancy hours (e.g. after school activities and night/weekend special events). Note that IDS will require read-only access to the control system, preferably remotely, to perform this task.
10. Review the customized data feed definitions for occupant dashboards to assure all pertinent data is made available.
11. Perform preliminary operational review to confirm major themes of operation are consistent with specification. Note that this is not a full operational evaluation as the school is not occupied and may not be running in normal occupied mode. Document any non-conformant findings, deliver findings via presentation format to all required parties.

Close-Out and Warranty Period *(one year from substantial completion for each of the three phases of construction)*

- Review system operation per acceptance criteria defined in Design Phase.
- Configure remote monitoring and analytics software utilizing data provided from the building management and control system.
- Ensure configuration of analytics and fault detection to operational acceptance criteria.
- Perform quarterly reviews and provide report of findings of operational evaluations against operational acceptance criteria with a goal that the building operates consistent with design intent by the end of the warranty period.
- Evaluate the programming codes to compare the performance per acceptance criteria defined in Design Phase.
- Provide training to facilities staff and Commissioning Agent on navigation and interpretation of remote monitoring software.

During each close out/warranty of AHS Project Phases 1, 2, and 3 IDS will perform the following scope of services. See Work Plan for additional details.

1. IDS plans to complete configuration of analytics and fault detection near the end of the construction phase with the intention to have it fully vetted by the start of this period. If not, configuration will occur at beginning of this period.
2. Training for the commissioning agent is also planned for the end of construction and facilities staff are encouraged to attend.
3. There will be four quarterly reviews (one per season) of operational data compared against pass/fail acceptance criteria. For each review IDS will:
   a. Perform pass/fail against acceptance criteria created in the design phase (see Attachment 2).

   b. Use the most appropriate week(s) of data within the quarter to evaluate sequence implementation.
   c. Present results of assessment to personnel designated by owner.
   d. The root cause for failure will be identified and presented to expedite remediation in the case where root cause is obvious. For situations where investigation is required to determine root cause and remediation approach, a separate scope may be required.
   e. All quarterly review presentation materials, along with corresponding video recording, will be stored in EnergyWitness' document library. The video captures the narrative and questions and answers during the session.
4. Training for Facilities personnel during this period (see work plan for timing).
   a. Training Session 1 covers the following topics:
      i. Mechanical Design Intent.
      ii. ASHRAE High Performance Sequences of Operation.
      iii. Findings from Preliminary Operational Analysis will be used for subject matter training material.
      iv. Alarm Hierarchies.
      v. Metering Reports.
      vi. Review Operational Acceptance Matrix and Pass/Fail Criteria.
      vii. EnergyWitness introduction, when to use BAS to trouble shoot, when to use EnergyWitness.
      viii. Working with IDS.
   b. Training Session 2
      i. Review of operational findings and building performance during first quarter (weeks will be selected to high light key operational concepts).
      ii. Using EnergyWitness and evaluation criteria to assess operations.
   c. Training Session 3
      i. Review of operational findings and building performance during second quarter (weeks will be selected to high light key operational concepts).
      ii. User requested topic training or IDS suggested topic.
   d. Training Session 4
      i. Review of operational findings and building performance during third quarter (weeks will be selected to high light key operational concepts).
      ii. User requested topic training or IDS suggested topic.
   e. Training Session 5
      i. Review of operational findings and building performance during fourth quarter (weeks will be selected to high light key operational concepts).
      ii. User requested topic training or IDS suggested topic.

5. Determine hot/cold call root cause during warranty period as requested by AHS.

Ongoing Monitoring and Optimization *(Provide a separate annual fee for this service)*

- Provide training to facilities staff.
- On-going monitoring service to include quarterly review of operations against design intent. Recommend remediation actions to achieve operational goals if required.
- Identify equipment deficiencies and advise facility personnel.
- Determine and present findings and suggest cause of hot/cold calls. Recommend remediation approach based on analysis of trend data from the Remote Monitoring software.

Ongoing Monitoring will commence upon completion of the warranty period for each project phase. IDS will provide the following ongoing monitoring services:

1. Quarterly review of operations against operational evaluation criteria (pass/fail).
    a. In cases where deviations occur, IDS will determine cause of deviation and recommend actions required to bring the system into conformance.
    b. Support calls deemed urgent will be responded to in 24 hours.
    c. IDS will review data of reported hot/cold calls to determine root cause and recommend corrective actions.
    d. Upon request IDS will review data and present findings.
    e. Sessions are recorded and stored in the EnergyWitness document library.
2. Training included annually up to 12 hours of any of the following category:
    a. EnergyWitness usage such as ad hoc reporting, fault detection, diagnostics, and metering.
    b. Demonstrate root cause analysis process via case study method.
    c. Review design intent and SOO for any equipment type along with ASHRAE basis for SOO.
    d. Use EnergyWitness fault detection reports to identify equipment in need of repair.
    e. Use EnergyWitness Low Score report to prioritize equipment repair.
    f. Review metering reports correlating energy data to BAS operations.
    g. Data interpretation as case study examples.
    h. Provide specialized content based upon need for equipment such as energy recovery units, chilled beams, economizer operations, fume hoods, VAV box configurations, etc.
    i. Using EnergyWitness' built-in document repository.
    j. Working with IDS.
    k. Training sessions are recorded and stored in the EnergyWitness document library.
3. Ongoing Data Transfer Support – This service supports the ongoing collection of data into the BAS database and transfer of data to the EnergyWitness database.

   a. If BAS data export stops, IDS will notify AHS to contact the BAS contractor.
   b. If data transfer stops between BAS and EnergyWitness cloud-based repository, IDS will restore data collection including working with AHS IT personnel to correct issue.
4. During first year of ongoing monitoring IDS will create energy baselines that will automatically track weather-normalized energy usage as compared to the initial baseline year and calculate the cost impact (savings or additional spend).

EnergyWitness Energy Management and Analytics

As part of this contract IDS includes configuration, use, maintenance and training of the EnergyWitness analytics platform. The use of the software includes:

1. 24-hour access to the system for all designated personnel.
2. Energy, metering, and BAS trend data reports, fault detection, and diagnostics.
3. Ongoing data collection from the BAS.
4. Document repository where all pertinent engineering documents and IDS deliverables will be deposited.
5. EnergyWitness software functionality updates.

Requirements of Arlington

The following items will be required to support IDS during each phase

1. Design
   a. Engineering data, including space (area and volume) data and correlation of equipment to space(s) served.
   b. Design Intent review meeting.
   c. We anticipate five review meetings with BALA for our submittals.
2. Construction
   a. Correspondences from BAS vendor.
   b. Read-only access to BAS, remotely accessible preferred.
   c. BAS system capturing data locally, prepared for transfer to EnergyWitness.
   d. Internet access and firewall configuration able to transfer to cloud.
3. Warranty Period
   a. Remote read-only access to control system.
   b. Transfer of data from BAS system to EnergyWitness.
4. Ongoing monitoring
   a. Hot/cold call incident reporting.

Work Plan

Interval Data Systems Arlington High School Work Plan			
Start Date	Description	Completion Date	Invited Attendees
Design Phase (begin at award end 8/31/20)			
7/17/20	IDS access to latest mechanical and electrical drawings and SOO for review and preparation for design review meeting	7/17/20	
Meeting	Basis of Design review meeting with BALA and Kickoff Meeting	7/22/20	Required: IDS, BALA, CM, OPM, Cx, Owner Mgt (OM) Optional: Owner Facilities Staff (OFS)
7/22/20	IDS review of mechanicals and SOO--general information and first set of systems	7/29/20	
Meeting	First set of recommendations to BALA	7/29/20	Required: IDS, BALA, OPM Optional: CM, Cx, OM, OFS
7/29/20	IDS review of mechanicals and SOO--second set of systems plus metering	8/5/20	
Meeting	Second set of recommendations to BALA; Discuss feedback from 1st recommendations	8/5/20	Required: IDS, BALA, OPM Optional: CM, Cx, OM, OFS
8/5/20	IDS review of mechanicals and SOO--third set of systems	8/12/20	
Meeting	Third set of recommendations to BALA; Discuss feedback from earlier recommendations	8/12/20	Required: IDS, BALA Optional: CM, OPM, Cx, OM, OFS
Meeting	Final review/discussion with BALA prior to submission of 90% CD (if needed)	8/19/20	Required: IDS, BALA Optional: CM, OPM, Cx, OM, OFS
Transmittal	Transmit final version of all input for 90% CD	8/21/20	Transmit to: OPM, BALA, Cx, OM
8/27/20	IDS access to 90% CD	8/28/20	
8/28/20	IDS review of 90% mechanicals and SOO, identify changes from earlier input and incomplete areas	9/4/20	
Meeting	First set of 90% recommendations to BALA	9/4/20	Required: IDS, BALA, OPM, Cx Optional: CM, OM, OFS
9/4/20	IDS review of 90% mechanicals and SOO--remainder of SOO; IDS review of remainder of ATC System Specifications (non-SOO) including BAS graphics/user interface specifications	9/14/20	
Meeting	Second set of 90% recommendations to BALA; Discuss feedback from earlier recommendations	9/14/20	Required: IDS, BALA Optional: CM, OPM, Cx, OM, OFS
9/14/20	IDS final review on any sections of specification or SOO still incomplete; Creation of operational acceptance criteria	9/23/20	
Meeting	Final review/discussion with BALA prior to submission of completed CD for bid package	9/23/20	Required: IDS, BALA, OPM, Cx Optional: CM, OM, OFS
Transmittal	Transmit final version of all input for final CD/bid package	9/25/20	Transmit to: OPM, BALA, Cx, OM
9/25/20	Available for support during this period and for optional review of controls bids	11/19/20	

Phase 1 - Auditorium, STEAM and Partial Spine			
Construction (begin 11/19/20 end 1/6/22)			
11/19/2020	Available to respond to control contractor's questions	1/6/2022	
3/15/2021	Review of Control Contractor Control Drawings with findings (assume availabilty 3/15)	3/22/21	
Meeting	Recommend that control contractor demonstrate understanding of design intent and plan for implementing high performance SOO	5/3/21	Required: IDS, BALA, OPM, Control Contractor (CC) Optional: CM, Cx, OM
Transmittal	Provide OPM and owner with written assessment of control contractor's understanding	5/14/21	Transmit to: OPM, OM, BALA
9/1/2021	Checking automation code for terminal systems (5 different programs, assuming all are phase 1)	9/8/21	
Meeting	Present feedback of terminal systems automation code review	9/9/21	Required: IDS, CC, OPM, BALA Optional: CM, Cx, OM
10/11/2021	Enable data collection from control system to EnergyWitness (dependent up control system trending being enabled)	11/1/21	
11/3/2021	Creation of EnergyWitness Building Data Model (digital twin) and configure diagnostics (dependent on data collection being established)	11/10/21	
11/5/2021	Review of HVAC operating screens and metering reports within BAS	11/12/21	
Meeting	Present feedback of BAS operating screens and metering reports review	11/15/20	Required: IDS, CC, OPM, OM, Cx Optional: CM, BALA, OFS
Training Session	Support Cx agent by providing training to apply EnergyWitness to commissioning needs	11/17/21	Required: IDS, Cx Optional: OPM, BALA, CM, OM
11/1/2021	Verify ongoing data collection performing as required and Building Data Model working properly	12/10/21	
12/13/2021	Preliminary review of operational data for major themes of operation (may lapse into start of warranty period depending on substantial completion and turnover schedule)	1/14/22	
Meeting	Present feedback of preliminary review	1/19/22	Required: IDS, CC, BALA, OPM, OM, Cx Optional: CM, OFS
Close Out and Warranty Period (begin 1/6/22 end 1/6/23)			
1/6/22	Operator Support During Warranty Period - IDS will respond to operational questions from facilities staff during warranty period	1/6/23	
Training Session	First Training Session: Mechanical Design Intent, ASHRAE High Performance Sequences of Operation, Findings from Preliminary Operational Analysis, Alarm Heirarchies, Metering Reports. Note Facilities are invited to SOO meeting with BALA during design phase. EnergyWitness introduction, when to use BAS to trouble shoot, when to use EnergyWitness to trouble shoot.	1/26/22	Required: IDS, OFS Optional: OM, OPM, BALA
3/28/2022	Perform winter/Q1 operational evaluation against evaluation criteria	4/6/22	
Meeting	Delivery of winter/Q1 operational analysis compared to evaluation criteria and recommendations	4/7/22	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
Training Session	Second Training Session: Review of Winter Operational findings and building performance during first quarter (weeks will be selected to high light key operational concepts)	4/11/22	Required: IDS, OFS Optional: OM, OPM, BALA
6/27/2022	Perform spring/Q2 operational evaluation against evaluation criteria	7/12/22	
Meeting	Delivery of Q2 operational analysis compared to evaluation criteria and recommendations	7/13/22	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
Training Session	Third Training Session: Review Second Operational Findings and building performance during first quarter (weeks will be selected to high light key operational concepts)	7/20/22	Required: IDS, OFS Optional: OM, OPM, BALA
9/26/2022	Perform summer/Q3 operational evaluation against evaluation criteria	10/4/22	
Meeting	Delivery of summer/Q3 operational analysis compared to evaluation criteria and recommendations	10/5/22	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
Training Session	Fourth Training Session: Review Third Operational Findings and building performance during first quarter (weeks will be selected to high light key operational concepts)	10/12/22	Required: IDS, OFS Optional: OM, OPM, BALA
12/19/2022	Perform fall/Q4 operational evaluation against evaluation criteria	1/3/23	
Meeting	Delivery of fall/Q4 operational analysis compared to evaluation criteria and recommendations	1/4/23	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
Training Session	Final Training Session: Review Q4 Operational Findings and building performance during first quarter (weeks will be selected to high light key operational concepts)	1/6/23	Required: IDS, OFS Optional: OM, OPM, BALA

Phase 2 - Humanities, 3 Preschool/Class/Office Wing and Remainder of Spine			
Construction (substantial completion 8/4/23)			
1/6/2022	Available to respond to control contractor's questions	8/4/2023	
	Review new control drawings if necessary (proposal assumes drawings for all phases are completed as part of Phase 1 construction)		
5/30/2023	Enable data collection for Phase 2 points from control system to EnergyWitness (dependent up control system trending for Phase 2 being fully configured)	6/9/23	
6/12/2023	Update of EnergyWitness Building Data Model (dependent on data collection being established) and diagnostics with Phase 2 additions	6/15/23	
6/19/2023	Review of HVAC operating screens and metering reports within BAS for Phase 2	6/22/23	
Meeting	Present feedback of BAS operating screens and metering reports review	6/22/23	Required: IDS, CC, OPM, OM, Cx Optional: CM, BALA, OFS
Training Session	Support Cx agent by providing training to apply EnergyWitness to commissioning needs	6/23/23	Required: IDS, Cx Optional: OPM, BALA, CM, OM
6/12/2023	Verify ongoing data collection performing as required and Building Data Model working properly	8/4/23	
8/1/2023	Preliminary review of operational data for major themes of operation (may lapse into start of warranty period depending on substantial completion and turnover schedule)	8/17/23	
Meeting	Present feedback of preliminary review	8/18/23	Required: IDS, CC, BALA, OPM, OM, Cx Optional: CM, OFS
Close Out and Warranty Period (8/4/23 - 8/4/24)			
8/4/23	Operator Support During Warranty Period - IDS will respond to operational questions from facilities staff during warranty period	8/4/24	
Training Session	Training Session: Phase 2 Mechanical Design Intent, ASHRAE High Performance Sequences of Operation, Findings from Preliminary Operational Analysis, Alarm Heirarchies, Metering Reports.	8/22/23	Required: IDS, OFS Optional: OM, OPM, BALA
11/1/2023	Perform fall/Q1 operational evaluation against evaluation criteria	11/8/23	
Meeting	Delivery of fall/Q1 operational analysis compared to evaluation criteria and recommendations	11/9/23	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
2/5/2024	Perform winter/Q2 operational evaluation against evaluation criteria	2/8/24	
Meeting	Delivery of winter/Q2 operational analysis compared to evaluation criteria and recommendations	2/9/24	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
Training Session	Third Training Session: Review Second Operational Findings and building performance during first quarter (weeks will be selected to high light key operational concepts)	2/14/24	Required: IDS, OFS Optional: OM, OPM, BALA
5/1/2024	Perform spring/Q3 operational evaluation against evaluation criteria	5/7/24	
Meeting	Delivery of spring/Q3 operational analysis compared to evaluation criteria and recommendations	5/8/24	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
7/21/2024	Perform summer/Q4 operational evaluation against evaluation criteria	7/24/24	
Meeting	Delivery of summer/Q4 operational analysis compared to evaluation criteria and recommendations	7/25/24	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS

Phase 3 - Athletic Wing and Final Performing Arts			
Construction (begin)			
8/4/2023	Available to respond to control contractor's questions	9/6/2024	
	Review new control drawings if necessary (proposal assumes drawings for all phases are completed as part of Phase 1 construction)		
7/8/2024	Enable data collection for Phase 3 points from control system to EnergyWitness (dependent up control system trending for Phase 3 being fully configured)	7/17/24	
7/18/2024	Update of EnergyWitness Building Data Model (dependent on data collection being established) and diagnostics with Phase 3 additions	7/23/24	
7/22/2024	Review of HVAC operating screens and metering reports within BAS for Phase 3	7/26/24	
Meeting	Present feedback of BAS operating screens and metering reports review	7/29/24	Required: IDS, CC, OPM, OM, Cx Optional: CM, BALA, OFS
Training Session	Support Cx agent by providing training to apply EnergyWitness to commissioning needs	7/26/24	Required: IDS, Cx Optional: OPM, BALA, CM, OM
7/23/2024	Verify ongoing data collection performing as required and Building Data Model working properly	9/6/24	
8/28/2024	Preliminary review of operational data for major themes of operation (may lapse into start of warranty period depending on substantial completion and turnover schedule)	9/12/24	
Meeting	Present feedback of preliminary review	9/13/24	Required: IDS, CC, BALA, OPM, OM, Cx Optional: CM, OFS
Close Out and Warranty Period (9/6/24 - 9/6/25)			
9/6/24	Operator Support During Warranty Period - IDS will respond to operational questions from facilities staff during warranty period	9/6/25	
Training Session	Training Session: Phase 3 Mechanical Design Intent, ASHRAE High Performance Sequences of Operation, Findings from Preliminary Operational Analysis, Alarm Heirarchies, Metering Reports.	9/11/24	Required: IDS, OFS Optional: OM, OPM, BALA
12/1/2024	Perform fall/Q1 operational evaluation against evaluation criteria	12/4/24	
Meeting	Delivery of fall/Q1 operational analysis compared to evaluation criteria and recommendations	12/5/24	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
3/2/2025	Perform winter/Q2 operational evaluation against evaluation criteria	3/5/25	
Meeting	Delivery of winter/Q2 operational analysis compared to evaluation criteria and recommendations	3/6/25	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
Training Session	Third Training Session: Review Second Operational Findings and building performance during first quarter (weeks will be selected to high light key operational concepts)	3/11/25	Required: IDS, OFS Optional: OM, OPM, BALA
6/1/2025	Perform spring/Q3 operational evaluation against evaluation criteria	6/4/25	
Meeting	Delivery of spring/Q3 operational analysis compared to evaluation criteria and recommendations	6/5/25	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS
8/24/2025	Perform summer/Q4 operational evaluation against evaluation criteria	8/27/25	
Meeting	Delivery of summer/Q4 operational analysis compared to evaluation criteria and recommendations	8/28/25	Required: IDS, OM, OPM, BALA, CC Optional: Cx, OFS

Resumes of Proposed Individuals

All personnel assigned to this project predominantly work from the address below, or work from their respective homes during the COVID-19 pandemic:

Interval Data Systems, Inc.
135 Beaver Street, Suite 410
Waltham, MA 02452

Kevin Fuller

Project Role	Program Manager
Background	Kevin brings over 30 years of experience in enterprise-level database and analytic applications, the last 15 of which are focused in energy management and utilities. He manages product development, marketing, and several key customer implementations for IDS.
Relevant Project Experience	*Belmont Middle and High School:* Program manager for the automation consulting activities with Belmont. Working with BALA and the OPM to deliver updated SOO and specifications. Define acceptance criteria. In upcoming phases of the project will manage the controls code reviews, interactions with Cx, operational evaluations during warranty, and training for Belmont staff. *Commonwealth of Kentucky:* As program manager, leads the implementation and ongoing expansion of all aspects of Kentucky's Commonwealth Energy Management and Control System (CEMCS) implementation. Works closely with Kentucky to deliver a steady stream of building analyses, leading to over 900 ECMs identified and approximately $6 million in annual savings. *Duke University:* Leading Duke's expanding use of EnergyWitness for a unified analytics system combining BAS, meter, and physical plant data. System provides fault detection reports, detailed diagnostics, metering and energy reporting. Previously, led the implementation and management of Duke's utility billing system.
Previous Work History and Training	Verilytics, Inc., Vice President Enterprise portals & analytics software Softgoods Development, Inc., Vice President & Cofounder Information commerce software Praxis International, Director Data warehouse and replication software CompuServe Data Technologies, Director Data warehouse and enterprise applications Software House, Customer Support Manager Enterprise database management software

Gregory Cmar

Project Role	Lead SOO and Operational Analyst
Background	Greg is a cofounder IDS and its CTO. He is an authority in sequences of operation, controls logic, and operational performance of buildings, complemented by expertise in database and software technologies. Greg has performed countless SOO and energy analyses over the course of his career. He is one of the foremost experts in world on the application of sequences, and operational analysis through interval data. Greg is a voting member of the ASHRAE Guideline 36 committee. He also holds patent #5,566,084 for the process for identifying patterns of electric energy, effects of proposed changes, and implementing such changes in the facility to conserve energy.
Relevant Project Experience	*Belmont Middle and High School:* Led the effort to update the SOO for Belmont based on ASHRAE G36. Applied G36 sequences directly for systems that are covered by the guideline and adapted G36 approaches for equipment not yet covered (e.g. geothermal wells, VRF). Designed acceptance criteria. Will lead the technical review of the controls submittals and implemented code during the late part of the construction phase, and operational evaluations during warranty. *UMass Medical School:* Leads the effort to revise SOO, based on G36, to improve operations of a large, complex lab and research facility. Designed the building data model that allows UMass to continuously view their labs' air changes per hour (among many other diagnostics), which led to the ability to make dramatic energy reductions in these critical facilities. Leads the analyst team through ongoing building evaluations, automation reviews, and continued education. *Commonwealth of Kentucky:* Leads the ongoing efforts to onboard and evaluate new buildings. Provides SOO and operational reviews and recommendations. Has influenced the design and construction practices for Kentucky as well as helping local engineering firms improve their standard SOO practice. *Williams College*: Leading the review of sequences and operations for a large science building that has high energy usage. *Leggat McCall Properties:* Upgraded engineer's SOO for a large biological science building based on ASHRAE G36.
Previous Work History and Training	Circadian Software, Inc., Director Enterprise energy management systems ForPower, Inc., Dir. Engineering & Cofounder Energy conservation consulting Coneco Corp. (subsidiary of Boston Edison), Engineering Manager Energy services, energy auditing, and utility billing Enertech Systems, Vice President Energy monitoring and controls contractor Johnson Controls, Inc., TABS Manager Massachusetts Energy Office, Energy Conservation Engineer Honeywell, System Sales

Mike Gagne

Project Role	Data Modeler and SOO/Operational Analyst/Trainer
Background	Mike joined IDS in 2014 after spending eight years in the controls industry implementing controls systems from a variety of vendors. He worked as a software programmer and then in the central engineering group, who worked to standardize automation code delivery. Mike joined IDS to further his interest in seeing automation delivered properly.
Relevant Project Experience	*Commonwealth of Kentucky:* Constructs building data models (digital twins) for all new buildings added to Kentucky's system. Works with engineers as needed to capture missing data needed to organize equipment and correlate it to spaces within the buildings. Creates the detailed diagnostic screens, custom tailored to the mechanical design of the building. Also performs operational analysis on buildings and provides significant input to the SOO review process and suggested updates, bringing a field control contractor's perspective. *Duke University:* Builds the building data models and custom diagnostics as Duke adds additional buildings to their EnergyWitness installation. *Williams College*: Review sequences of operation and mechanical plans to provide input for improvements. Built the building data model and diagnostics for their science building. *Leggat McCall Properties:* Review SOO for biological sciences building and provide feedback to engineer.
Previous Work History and Training	*Control Technologies Inc.,* Central Engineering Software Engineer Independent controls contractor

David Silbermann

Project Role	IT Management
Background	David came to IDS six years ago with a Big 5 consulting background and over a dozen years of experience managing the design and construction of large scale, complex business systems. David works closely with customers and our development staff to ensure data is collected properly and any IT related functions operate fluidly.
Relevant Project Experience	*Commonwealth of Kentucky:* A key member of the team that implemented Kentucky's Commonwealth Energy Management and Control System (CEMCS). Involved from design through implementation and statewide expansion. David is the primary point of contact with Kentucky's Office of Technology (IT group). He worked closely with administrators, the security team, and networking groups to get data collection established and flowing consistently. *UMass Medical School:* Provides IT support for ongoing data collection, system administration, and user access. *Duke University:* Maintains the relationship with Duke's Office of Information Technology for issues related to servers, network and data collection into EnergyWitness. Configures BACnet data collection system. *Williams College*: Interfaces with Williams' controls staff and their external controls contractor to set up and manage ongoing data collection.
Previous Work History and Training	ConnectEDU, Sr. Project Manager SaaS platform for college admissions Monster Worldwide, Sr. Program Manager Global online employment solution Digitas, Associate Director Digital Marketing Agency BladeLogic, Project Manager Data center management software Accenture, Technology Consultant / Manager Technology-based business solutions Certified Project Management Professional (PMP)

References

Belmont Middle and High School

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UMass Medical School

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UMass Medical School
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Cost Proposal

Project Phase	Fee
Design Phase	$46,000.00
AHS Project Phase 1 Construction and Project Close/Warranty	$81,000.00
AHS Project Phase 2 Construction and Project Close/Warranty	$40,000.00
AHS Project Phase 3 Construction and Project Close/Warranty	$28,000.00
Total	**$195,000.00**

Ongoing Monitoring	Annual Fee
AHS Project Phase 1 (Begin 1/06/23)	$22,500.00
AHS Project Phase 2 (Begin 8/04/24)	$8,500.00
AHS Project Phase 3 (Begin 9/06/25)	$5,000.00

Note: Ongoing Monitoring annual fees include use of EnergyWitness software and services defined herein.

Attachment 1: Work Sample—Pages from Updated SOO

The following pages are a sample of work updating the SOO for Belmont Middle and High School. There are three pages (out of 10) of the updated General section, and the first three pages related to the Heat Recovery Units. In total, the original work product this sample was taken from was 90 pages.

4.29 SEQUENCES OF OPERATION

A. The following sequences of operation shall be met and applicable to all equipment, instrumented with DDC controls. Provide all devices, wiring, instrumentation, software, programming, testing, and verification, complete in all respects to assure an effective, repeatable and adjustable system. The overview is intended to be general in nature; refer to detailed sequences, plans, and specification sections for the various components.

1. General and Common Characteristics

a. This specification contains references to ASHRAE G36, or simply G36, which refer to ASHRAE Guideline 36-2018, *High-Performance Sequences of Operation for HVAC Systems.*

b. Zone Groups (see ASHRAE G36 5.4)

The primary mechanism system operators will use to manage occupancy scheduling of BMHS will be zone groups. Access to Zone Group management screens will be within one-click of the BMS home page. The home Zone Group graphic display shall include its operating Mode.

1) Each system shall be broken into separate Zone Groups composed of a collection of one or more zones served by a single air handler.

Initial candidates for zone groups will be developed from the following areas found in the mechanical drawings.

Mechanical Sheet	Title	Area Served	HVAC Equipment Types
M11-01A	HVAC Level 01 - Area A	Admin Office Area - HS	AC, FCU, CUH, HRB, VFCU
M11-01B	HVAC Level 01 - Area B	Auditorium Area	CUH, FCU, VAV, VCEV
M11-01C	HVAC Level 01 - Area C	Pool Area	CUH, UH, AC, CB, VAV, VCEV
M11-01D	HVAC Level 01 - Area D	Art Area	AC, CUH, CB, VAV, VCEV
M11-01E	HVAC Level 01 - Area E	Locker Room Area	AC, EUH, HVAC-2
M11-01F	HVAC Level 01 - Area F	Admin Office Area - MS	FCU, VFCU, CUH, CB, VAV, VCEV
M11-02A	HVAC Level 02 - Area A	9-12 Classrooms - HS	RCP, FCU, CB, VAV, VCEV
M11-02B	HVAC Level 02 - Area B	9-12 Media Center	FCU, CB, VAV, VCEV
M11-02C	HVAC Level 02 - Area C	9-12 Media Center/Physics Classrooms	AC, FCU, CB, VAV, VCEV
M11-02D	HVAC Level 02 - Area D	7-8 Classrooms 7-8 Media Center - MS	FCU, CB, VAV, VCEV, HVAC-2
M11-02E	HVAC Level 02 - Area E	Small Gym	HV, ERV, ACCU, AC
M11-02F	HVAC Level 02 - Area F	7 Classrooms - MS	FCU, CB, VAV, VCEV
M11-03A	HVAC Level 03 - Area A	9-12 Classrooms - HS	EUH, FCU, CB, VAV, VCEV
M11-03B	HVAC Level 03 - Area B	9-12 Classrooms - HS	AC, FCU, CB, VAV, VCEV
M11-03C	HVAC Level 03 - Area C	Physics Maker Space/8 Classroom	RCP, CB, VAV, VCEV
M11-03D	HVAC Level 03 - Area D	8 Classroom/Maker Space - MS	AC, FCU, CB, VAV, VCEV
M11-03F	HVAC Level 03 - Area F	7-8 Classrooms/8 Classrooms - MS	FCU, CB, VAV, VCEV
M11-04A	HVAC Level 04 - Area A	9-12 Classrooms - HS	RCP, FCU, CB, VAV, VCEV
M11-04B	HVAC Level 04 - Area B	9-12 Classrooms -HS	FCU, CB, VAV, VCEV
M11-04C	HVAC Level 04 - Area C	9-12 Classrooms/Chemistry - HS	AC, CB, VAV, VCEV
M11-04D	HVAC Level 04 - Area D	9-12 Classrooms/Chemistry - HS	CB, VAV, VCEV

2) Each Zone Group shall be capable of having separate occupancy schedules and Operating Modes from other Zone Groups.

- A Zone Group shall be capable of including shared, supporting Zone Groups; e.g., a classroom Zone Group may also activate a restroom Zone Group.

3) All zones in each Zone Group shall be in the same Zone Group Operating Mode as defined below. If one zone in a Zone Group is placed in any Zone Group Operating Mode other than Unoccupied Mode (due to override, sequence logic, or scheduled occupancy) all zones in that Zone Group shall enter that mode.

4) A Zone Group may be in only one mode at any given time

5) For each Zone Group, provide a set of testing/commissioning software switches that override all zones served by the Zone Group. Provide a separate software switch for each of the zone-level override switches listed under "Testing and Commissioning Overrides" in terminal unit sequences. When the value of a Zone Group's override switch is changed, the corresponding override switch for every zone in the Zone Group shall change to the same value. Subsequently, the zone-level override switch may be changed to a different value. The value of the zone-level switch has no effect on the value of the Zone Group switch, and the value of the Zone Group switch only affects the zone-level switches when the Zone Group switch is changed.

c. Modes of Operation

Each Zone Group shall have the following modes:

1) **Occupied Mode**: A Zone Group is in the Occupied Mode when any of the following is true:

- The time of day is between the Zone Group's scheduled occupied start and stop times.
- The schedules have been overridden by the Occupant Override System.
- Any zone local override timer (initiated by local override button) is nonzero.

2) **Warmup Mode**: For each zone, the BMS shall calculate the required warm up time based on the zone's occupied heating setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. Zones where the window switch indicates that a window is open shall be ignored. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned on or off by a software switch, to allow tuning to be stopped after the system has been trained. Warmup Mode shall start based on the zone with the longest calculated warm up time requirement, but no earlier than 3 hours before the start of the scheduled occupied period and shall end at

the scheduled Occupied start hour.

3) **Cool-Down Mode**: For each zone, the BMS shall calculate the required cool down time based on the zone's occupied cooling setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. Zones where the window switch indicates that a window is open shall be ignored. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned on or off by a software switch, to allow tuning to be stopped after the system has been trained. Cool-down Mode shall start based on the zone with the longest calculated cool-down time requirement, but no earlier than 3 hours before the start of the scheduled occupied period and shall end at the scheduled Occupied start hour.

4) **Setback Mode**: During Unoccupied Mode, if any 5 zones (or all zones, if fewer than 5) in the Zone Group fall below their unoccupied heating setpoints the Zone Group shall enter Setback Mode until all spaces in the Zone Group are 1satisfied.

- The setback temperature setpoint for all zones shall be adjusted according to an outside temperature reset schedule.

OAT	35°F	5°F
Setback T	Unc Heating Stpt	Occ Heating Stpt

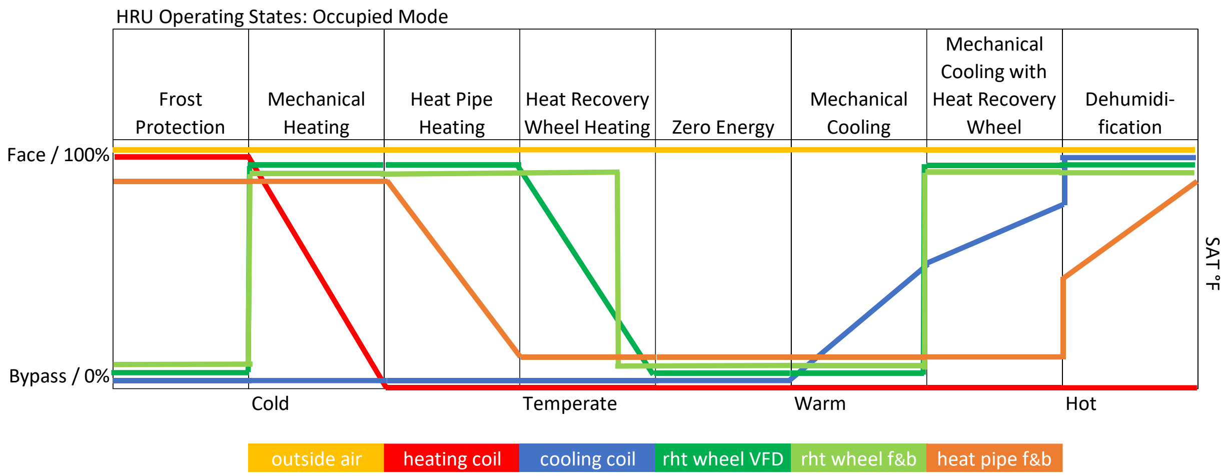
5) **Freeze Protection Setback Mode**: During Unoccupied Mode, if any single zone falls below 4°C (40°F), the Zone Group shall enter Setback Mode until all zones are above 7°C (45°F), and a Level 3 alarm shall be set.

6) **Setup Mode**: During Unoccupied Mode, if any 5 zones (or all zones, if fewer than 5) in the Zone rise above their unoccupied cooling setpoints or if the average zone temperature of the Zone Group rises above the average unoccupied cooling setpoint, the Zone Group shall enter Setup Mode until all spaces in the Zone Group are 1°C (2°F) below their unoccupied setpoints. Zones where the window switch indicates that a window is open shall be ignored.

7) **Unoccupied Mode**: When the Zone Group is not in any other mode.

B. Heat Recovery HVAC Units - HRU-1 through HRU-6:

1. HRU Operating States: Occupied Mode



a. **Frost Protection**—Frost Protection Operating state is activated when conditions (to be defined) indicate that the Heat Recovery Wheel cannot acquire sufficient exhaust air heat to overcome the outside air ability to cool the air stream below freezing. The reheat wheel bypass damper will be opened and the reheat wheel VFD speed reduced to its lowest speed.

b. **Mechanical Heating**—When Mechanical Heating Operating state is active the Reheat Wheel and Heat Pipe shall be at full output. Heating control valve shall modulate in order to maintain the supply air temperature set point.

c. **Heat Pipe Heating**—In the Heat Pipe Heating state, the face and bypass dampers shall modulate to maintain the supply air temperature set point.

d. **Heat Recovery Wheel Heating**—During the Heat Recovery Wheel operating state, the heat wheel drive speed shall modulate to maintain the supply air temperature set point. When the SAT is within the heat recovery rate of the heat wheel, the bypass damper shall open in order to allow to the heat wheel it closest approach to its set point.

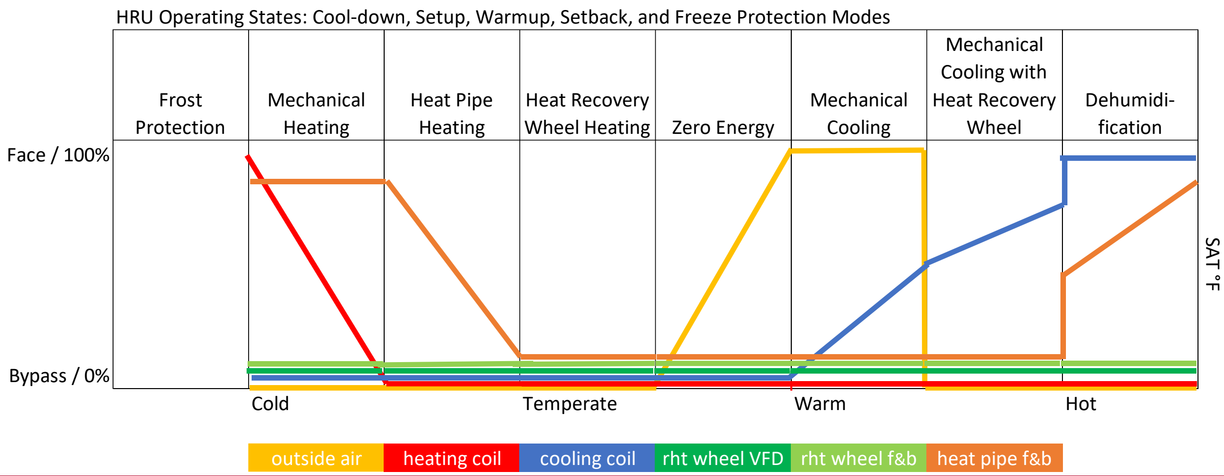
e. **Zero Energy**—Zero energy state occurs when the SAT setpoint can be achieved without any additional heating or cooling. Heat Pipe and Reheat Wheel dampers are in bypass.

f. **Mechanical Cooling**—During the Mechanical Cooling stage, SAT set point is maintained by modulating the cooling coil control valve. Heat Pipe and Reheat Wheel dampers are in bypass.

g. **Mechanical Cooling with Heat Recovery Wheel**—When the enthalpy of the return air is less than that of outside air, the Heat Recovery Wheel shall be activated, and its dampers put in face position.

h. **Dehumidification**—When space temperature conditions indicate that the chilled beam system is at or near condensation conditions, the air handler shall be place into Dehumidification state, the cooling valve opened 100% and Heat Pipe face and bypass damper modulated to maintain the SAT setpoint. Mechanical Cooling with Heat Recovery Wheel remains in full operational state.

2. HRU Operating States: Cool-down, Setup, Warmup, Setback, and Freeze Protection Modes (i.e. non-occupied modes)



a. **Frost Protection**—Frost Protection Operating State is not required unless the unit is in Occupied Mode.

b. **Mechanical Heating**—When Mechanical Heating Operating state is active the Reheat Wheel and Heat Pipe shall be at full output. Heating control valve shall modulate in order to maintain the supply air temperature set point.

c. **Heat Pipe Heating**—In the Heat Pipe Heating state, the face and bypass dampers shall modulate to maintain the supply air temperature set point.

d. **Heat Recovery Wheel Heating**—Heat Recovery Wheel Operating State is not required unless the unit is in Occupied Mode.

e. **Zero Energy**—Zero energy state occurs when the SAT set point can be achieved without any additional heating or cooling. Heat Pipe and Reheat Wheel dampers are in bypass.

f. **Mechanical Cooling**—During the Mechanical Cooling stage, SAT setpoint is maintained by modulating the cooling coil control valve. Heat Pipe and Reheat Wheel dampers are in bypass.

g. **Mechanical Cooling with Heat Recovery Wheel**—Mechanical Cooling with Heat Recovery Wheel Operating State is not required unless the unit is in Occupied Mode.

h. **Dehumidification**—When space temperature conditions indicate that the chilled beam system is at or near condensation conditions, the air handler shall be place into Dehumidification state, the cooling valve opened 100% and Heat Pipe face and bypass damper modulated to maintain the SAT set point.

~~1.~~3. In Occupied Mode

a. Returning air is drawn via the return/exhaust fan, over pre-filters and through a sensible heat pipe coil, the energy recovery wheel then discharged to atmosphere. This returning air to be extracted and exhausted, may also include toilet exhaust air for heat recovery.

b. The wheel will operate based on need for recovery.

c. Outside air is drawn in via the supply fan, through filters and through the energy recovery wheel, operating per requirements. Air then passes through the dual temperature hot/chilled water coil and the sensible heat pipe coil. Depending on requirements, the air will be heated or cooled to the scheduled discharge air temperature, as indexed by outdoor air temperature or building demand.

~~2.~~4. ~~Unit OFF/Disabled Mode (~~Transition to Unoccupied Mode~~)~~

a. Exhaust, supply and outside air dampers shall be closed.

b. Exhaust fan and supply fan shall be deenergized.

c. Enthalpy wheel shall be deenergized.

d. Wheel bypass dampers shall be closed (normally closed).

e. Recirculation damper shall be closed (normally closed).

f. Chilled water and hot water isolation and modulating valves shall be closed.

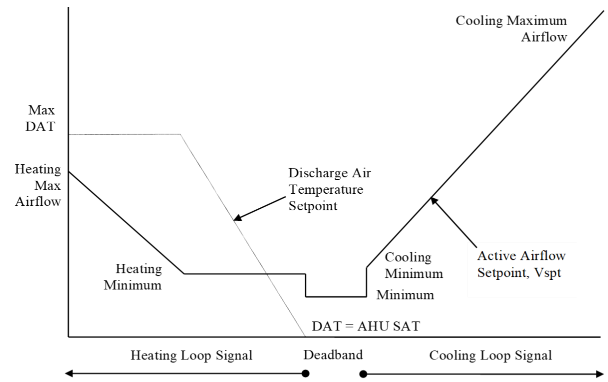
~~f.~~g. SystemOK flag set to false

~~g.~~h. Pumping, Primary Plant requests set to 0

Attachment 2: Work Sample—Acceptance Criteria Matrix

The following is a sample of the acceptance criteria matrix for VAV boxes.

Terminal Systems: VAV



Sub System	Sequence / Check	Pass	Fail	N/A	Analyst Comments
Graphics					
	All equipment for zone is displayed on single screen				
	Alarm summary on screen with zone equipment				
	Zone equipment properly shown				
Airflow/Damper Control					
	System follows startup sequence				
	System follows shutdown sequence				
	At dead band, airflow is at minimum				
	Damper maintains cfm set point				
	Static pressure reset uses Trim & Respond				
Cooling Control					
	Heating valve is closed in Cooling State (unless DAT < 50°F)				
	Airflow set point adjusts to meet space cooling demand				
Heating Control					
	Heating valve and airflow follow sequence				
	DAT does not exceed Max DAT				
Comfort					
	Zone temperature meets set points				
	Zone humidity meets set point				
Ventilation Control					
	Calculate uncorrected outdoor air rate (V_{OU}) when in Occ mode				
	Calculate zone primary outdoor fraction (Z_{pz}) when in Occ mode				
	Ventilation level adjusts based on occupancy sensor input				
	Ventilation level adjusts based on CO_2				
	Minimum cfm OA delivered				
Program Control					
	Zone has Importance Multiplier				
	Zone has Request-Hours Accumulator				
	Generates SAT reset requests				
	Generates hot water reset requests				
	Generates static pressure reset requests				
Zone Groups					
	Participates in a zone group				
	Operates in compatible Mode of Operation as other members of zone group				
Trending (finalize point list after equipment selected)					
	Airflow (cfm)				
	Effective airflow set point (cfm)				
	Discharge air temperature (°F)				
	Zone temperature (°F)				
	Effective zone temp set point (°F), OR (Effective heating set point (°F) AND Effective cooling set point (°F))				
	Heating valve (% open)				
	Damper position (% open)				
	Occupied status (binary)				
	Zone humidity (% RH)				
	Eff zone humidity set pont (% RH)				
	Zone CO_2 (ppm)				
	Zone CO_2 limit set point (ppm)				
	Static pressure requests (#)				
	SAT cooling requests (#)				
	Heating-cooling mode (binary)				
	Heating loop output (%)				
	Cooling loop output (%)				